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Financing energy access and off-grid electrification: A review of status, options and challenges

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This paper provides a review of funding needs and financing mechanisms for energy access in general and off-grid electrification in particular to find whether the funding for these activities has been adequate, whether sufficient funding is likely to be available to meet the needs of universal energy access, whether innovative approaches can be used in funding. It finds that in all successful cases the state has played an important role in funding infrastructure investments but many developing countries have neglected the energy access issue for a long time. International donor agencies have provided selective and limited support, while the innovative mechanisms are also unfriendly towards small-scale projects. Weak governance, limited organisational capacity and unfavourable policy environment militate against large-scale mobilisation of financial resources in the poorest countries of the world where energy access is a chronic problem. The challenge of mobilising finance and ensuring its appropriate delivery and use remains a major issue and would require a co-ordinated effort of all relevant stakeholders.

Contents

1. Introduction

The Sustainable Energy for All initiative of the Secretary General of the United Nations (UN) in 2012 has crystallised the global attention on the energy access challenge. As countries set targets for achieving sustainable energy supply for all by 2030, it becomes evident that an unprecedented level of investment will be required for financing electrification projects or clean cooking energy supply to realise these objectives. The manifestation of severe energy access challenge at present reflects the inadequacy of existing efforts by governments, international financial agencies, donor agencies and the private sector in funding energy

Abbreviations: AAU, Assigned Amount Unit; ADB, Asian Development Bank; AfDB, African Development Bank; AGF, Advisroy Group on Climate Change Financing; CDM, Clean Development Mechanism; CER, Certified Emissions Reduction; CIF, Climate Investment Funds; ESCO, Energy Service Company; ETS, Emissions Trading System; FDI, Foreign Direct Investment; GCFC, Gross Fixed Capital Formation; GEF, Global Environment Facility; IEA, International Energy Agency; LDC, Least Developed Countries; LPG, Liquefied Petroleum Gas; NIE, Neo-Institutional Economics; ODA, Overseas Development Assistance; ODF, Overseas Development Finance; OECD, Organisation of Economic Cooperation and Development; PoA, Programme of Activities; PV, Photo Voltaic; SHS, Solar Home Systems; SME, Small and Medium Enterprises; UN, United Nations

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supply provisions and the likelihood of continuation of such a situation in the absence of any concerted policy interventions [1][1] clearly calls for a radical shift in funding priorities and mechanisms.

Yet, there has been a long tradition of supporting rural electrification programmes and clean cooking energies but the intervention mechanisms, the funding arrangements and the focus have changed over time. For example, the focus has changed from a supply-driven financing approach to demand-side where micro-finance has emerged to cater to the financial needs of the users. Similarly, the evolution of financial markets and the emergence of new opportunities to address issues related to the environment and climate change have led to new funding instruments and intervention mechanisms. Concurrently, it needs to be recognised that the funds have to flow to some of the poorest countries of the world which are characterised by weak governance, poor policy environment and limited organisational and institutional capacities.

Although some recent studies have considered the financial challenges facing universal energy access provision, there is a gap in terms a systematic and critical review of financing issues and options. Three recent studies [1–3] provide a macro perspective either by considering the funding needs and possible funding flow (e.g., [1,2], or by identifying international financial flows to the energy sector [3]. However, [1] provides a single set of estimates and does not really provide a critical analysis, while [2] provides a set of alternative estimations of the investment needs but not a critical analysis of the funding challenge. A few others provide a particular perspective: [4] focuses on the potential for private sector to play a role; [5,6] provide a micro picture considering the stakeholder perspectives from a survey; [7–9] provide country case studies for Nepal, Sri Lanka and Senegal, respectively. [10,11] provide an overview of financing portfolio of Asian Development Bank and World Bank, respectively. Yet, to the best of our knowledge, there is no systematic review of financing issues and options for electrification in developing countries. This paper bridges the gap through a comprehensive review by considering the financing needs, potential financial flows, challenges and options for financing. It also considers specific financing options for off-grid electrification and cooking energy provisions.

The paper is organised as follows: the second section presents the scale of the challenge by considering the financing needs for energy access for all and by identifying the financial sources and financial flows; Section 3 discusses financial options and financing challenges, Section 4 explores financing mechanisms specifically for off-grid electrification. Finally, Section 5 provides some concluding remarks.

2. Scale of the problem

This section critically reviews the overall investment needs, financial flows in the past and possible funding sources for universal energy access. The section is divided into three subsections around the above themes.

2.1. Investment needs for energy access for all

It is estimated that more than 1.3 billion people in the world in 2009 did not have access to electricity and 2.7 billion did not have access to clean cooking energies [1]. An estimated $9.1 billion was invested in providing access to energy in the same year (i.e., 2009)—of which only $70 million went to provide advanced biomass cook-stoves (benefitting 7 million people) and the rest was used in providing access to electricity to 20 million people [1]. The imbalance in priorities for electricity and clean cooking energy investments is clearly visible as is the per person investment needs for two types of access. It was further estimated in [1] that multi-lateral agencies contributed 34% of the above investment, followed by 30% from the developing country governments, 22% from private sector and 14% of the above investment came from bi-lateral official development assistance [1].

A number of estimates are now available in the literature highlighting the financial challenge facing universal energy access but the origin and genesis of these numbers cannot always be traced. A commonly quoted figure is $35–40 billion average annual investment to achieve basic universal energy access by 2030 [11,32] but as such figures do not lend themselves to any further scrutiny, we have not considered them here. We do not include any study that focuses only on national cost estimates (e.g., [9] or does not focus on universal energy access (e.g., [14][2] or [15][3]) per se. Instead, we first consider estimates given in [1] and subsequently consider some other key studies such as [2,17].

Two essential scenarios are considered in [1]:

(a) In its New Policy scenario the International Energy Agency (IEA) estimates that $15 billion per year will be invested between 2010 and 2030 to provide energy access (or a total $296 billion for the period). About $14 billion per year will go towards electricity access and just $1 billion per year will be invested in clean cooking energy provision to connect 26 million people to electricity supply each year, while 860 million additional people will gain access to cooking energy by the end of 2030. Out of $14 billion annual investment in electricity, 55% is likely to be invested in on-grid electricity supply while 45% will go to the off-grid sector. Yet, such a level of investment will not be sufficient to ensure energy access to all—by 2030, about 1 billion people will still lack access to electricity and 2.7 billion will not have access to cooking energies. This implies that even with a 50% increase in investment in energy access provision, the gravity of the problem is likely to change marginally.

(b) The alternative scenario which targets to achieve universal energy access by 2030 requires an annual investment of $48 billion, a five-fold increase in the investment compared to that in 2009. The total investment need increases to $1 trillion in this case but this is still a very small amount compared to the overall energy sector investment needs globally, which has been estimated at $37 trillion by [12] for the same period. Electricity access will still have a larger share in the overall investment need (almost 90% of the total) but investment in cooking energy will proportionally increase and will require $95 billion over the next two decades.

Although the above estimate provides a detailed picture, it needs to be emphasised that like any estimate, this one is also based on assumptions of cost, rate of access, and technology selection. It was assumed that 50% of the Private Public Partnership funding for energy infrastructure came from the private sector and that between 5 and 20% of the private sector funds went to enhance energy access. However, most of the private sector projects were large power generation projects, which are

[1] [1] indicates that in the absence of new policy interventions 1 billion people will still lack electricity access by 2030 while 2.7 billion will not have access to clean cooking energies by 2030.

[2] This study focuses on Africa's electricity investment needs under different scenarios but does not consider universal energy access. The time horizon is also limited to 2015.

[3] This study uses [16] referred to above and focuses on overall sectoral investment but not on universal energy access.

unlikely to qualify as energy access investments. Therefore, this estimate is questionable. Similarly, one of the assumptions regarding government funding is that governments provided matching funds for every dollar of Overseas Development Assistance (ODA) support. This appears to be a bold assumption, to say the least. Clearly, the above estimates need to be considered with caution. Also, these are point estimates and no range is given. Moreover, IEA estimate does not include the infrastructure related costs for cooking energy access and covers investment costs in stoves, digesters, etc. Therefore, these estimates should be taken as approximate figures and considered with care.

In contrast to a point estimate of [1], estimates for three scenarios of energy access, namely low, medium and high are presented in [2]. Their cost estimates for universal electricity access are based on the following assumptions: (a) full levelised cost of generation is considered but transmission and distribution-related costs are not considered; (b) the levelised generation costs are based on IEA studies; (c) estimates for three scenarios correspond to different consumption levels varying from basic to the current average residential consumption in Latin America;(d) the electrification rates in 2008 is considered as the base level and universal electricity access for urban and rural population by 2030 is considered; and (e) urban access is provided through grid extensions while rural access is provided through an arbitrarily chosen mix of grid extension, mini-grids and off-grid options.

The results show that the annual investment requirement will be $12 billion in the low scenario, $60 billion in the medium scenario and $134 billion in the high scenario [2]. While the low estimate is comparatively lower than that in [1], the middle estimate is closer to the estimate in [1] while the other estimate is much higher than that of [1]. This suggests the possibility of significantly higher level of investment needs for providing access.

An indicative estimate of investment requirement for enhancing energy access in Africa is found in [17]. It assumed that 90% of the rural population in Sub-Saharan Africa and 100% of the rest (including urban population of SS-Africa) will have access to electricity by 2030. It was estimated that $547 billion (constant 2005 terms) [or an annual investment of $24 billion] will be required for generation, transmission and distribution of electricity for the period between 2008 and 2030 to ensure electricity access in the region and that 265 GW of new generation capacity will be required to ensure energy access. This study did not focus on cooking energy needs and did not include costs related to fuel supply system improvements.

The investment needs for energy access is dependent on assumptions of technology choice. According to [1], mini-grids and off-grid technologies are to be deployed in 70% of the rural areas where $6 billion per year will be required for mini-grid and off-grid electrification in the New Policy Scenario but an additional annual investment of $20 billion is required for off-grid options between 2010 and 2030 to ensure universal electrification [1]. However, the investment is likely to be back-loaded, implying a higher amount of flow required as 2030 approaches. Mini-grids are likely to have a major share in the off-grid systems, while isolated off-grid systems will cater to about 20% of the population without electricity access. About 60% of the investment would go to Sub-Saharan Africa where the electricity access is relatively low at present. The largest share of cooking energy access will come from biogas plants while the rest will be shared between LPG (liquefied petroleum gas) and advanced cookstoves. Almost two-thirds of the investment for cooking energy access will be needed in Asia and the rest will be needed in Sub-Saharan Africa.

Off-grid electrification has received attention in recent times as a possible electrification option for remote rural areas of developing countries. According to [21] a large number of solar lighting systems are operating throughout the world: more than 500,000 solar photo voltaic (PV) systems were in use in 2007 in Africa, more than 400,000 solar home systems (SHS) were sold in China by 2008, more than 600,000 SHS and 800,000 solar lamps were in use in India by 2010, 125,000 SHS in Sri Lanka and 30,000 SHS in Bangladesh [21]. Using a spatial least-cost analysis framework, [18] identified that decentralised off-grid options can be a cost-effective option in many parts of Africa and that if the affordability of consumers can be increased or cost of supply is reduced, off-grid options can surely play an important role. Others supporting an important role of off-grid system in universal electrification of Africa include [19,20]. [19] reports an investment requirement of $3.4 billion per year for off-grid systems to deploy approximately 12 GW of off-grid capacity. However, the above estimate is based on a basic level of access and is not directly comparable with estimates of [1].

The above clearly shows the looming financing challenge for energy access in general and off-grid electrification in particular. We now turn to financial flows to see how these needs can perhaps be met.

2.2. Financial flows to enhance energy access

This section provides a review of four sources of funds, namely public sources, international development assistance, private capital and new sources of finance such as carbon finance.

Based on data compiled by [3], it can be seen that the Gross Fixed Capital Formation (GFCF) for electricity and gas distribution has been rising steadily over the past decade (between 2000 and 2009, see Fig. 1). On a global level, the investment in electricity and gas distribution increased from $232.6 billion (constant 2000 terms) to $316.6 billion. The share of the developing countries has increased substantially during this period: from just 23% in 2000 to 46% in 2009, but the capital investment in the Least Developed Countries (LDC) remained very insignificant—$2.6 billion in 2009 (less than 1% of global investment).

The data on Foreign Direct Investment (FDI) in energy is more patchy and covers a number of types of transactions (such as merger and acquisition, greenfield projects, lease, etc.) that do not necessarily lead to new asset creation. Ref. [10] contends that $3.65 trillion flowed to developing economies between 1997 and 2008 and [3] notes that the FDI flow has declined over time. It is indicated in [10] that FDI has benefitted only certain countries that provided the enabling environment and that the poor countries did not benefit from the FDI. The data from the Private Participation in Infrastructure Database of the World Bank confirms this assertion (see Fig. 2) and suggests that the flow gradually increased until 1997 and then rapidly declined in the aftermath of the Asian financial crisis. The FDI flow improved

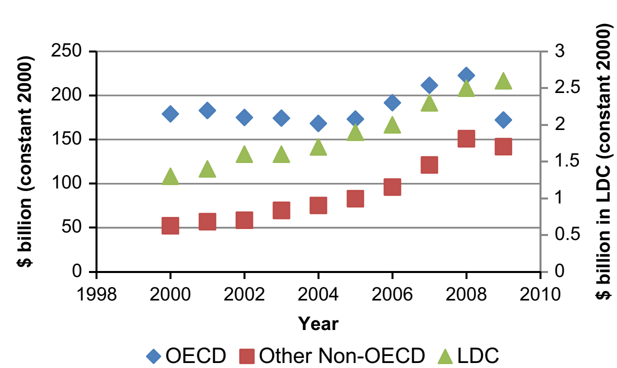


Fig. 1. Trend of gross fixed capital formation in electricity and gas distribution. *Note*: LDC—Least developed countries (as per UN categorisation). The data is presented using the right-hand scale.
Data source: [3].

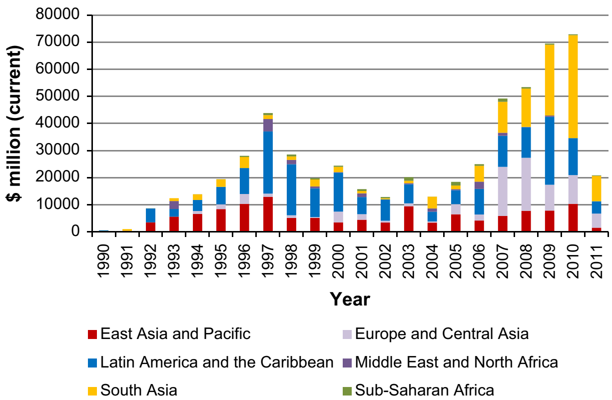


Fig. 2. FDI flow in energy infrastructure.
Data source: PPIAF database (World Bank).

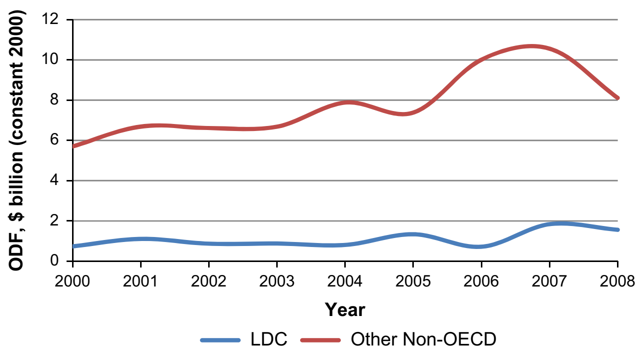


Fig. 3. ODF flow for energy generation and supply.
Data source: [3].

since 2007 for a short period when the global financial crisis has resulted in a major decline in the flow. Moreover, the FDI has only benefitted a selected set of countries (or regions), namely the Latin American countries in the pre-1997 period and Asia (South Asia, mostly India and China). FDI flow to Sub-Saharan Africa has remained insignificant and generally large electricity supply projects have benefited, making the funding less relevant for energy access purposes.

According to [10] OECD countries have provided almost $1 trillion as Official Development Assistance (ODA) for various purposes between 1997 and 2008 and this remains an important source of funding for developing countries.[4] However, only a small share of this funding goes to the energy sector. Moreover, the ODA for energy generation and supply declined in the 1990s amid widespread sector reform initiatives but since 2000, the flow has steadily increased and in 2008, ODF for energy represented $9.67 billion (constant 2000 terms) [3], see Fig. 3. A similar observation is made by [23]. Although, most of the ODF went to non-LDCs, the share of LDCs is showing an increasing trend: in 2000, LDCs received only 11% of the ODF while in 2008, it reached 16%.

Based on the above, it can be argued that only a fraction of ODF and FDI leads to new capital asset formation and that the foreign financial flows contributed partially towards countries' energy-related capital formation. The rest came from internal sources. Although the trend for each country is not clearly available, due to data constraints and inadequate focus on the issue in the academic literature, it is not difficult to imagine that financial constraints of poorer countries act as a hindrance towards gross capital formation in energy generation and supply.

In addition to FDI and ODF, development assistance from multilateral agencies is another source of funding for developing countries. [10] reported that these agenceis provided $94 billion between 1997 and 2008 covering various development activities. In the following paragraphs investments by three such organisations are reviewed.

(a) The World Bank group leads the funding from this group contributing almost 40% of the support. A review of the energy access portfolio of the World Bank group using Bank-financed project data reveals that the Bank has invested about $20 billion between 2000 and 2008 in energy-related projects but only about $4 billion (or one-fifth of the total) qualifies as energy access investments [25]. A steep rise in energy access funding in 2008 is noted: until 2007, the Bank invested between $250 and $520 million per year but in 2008, this reached $1.15 billion [25]. Whether this rise is an abberation or not cannot be verified from the report. It further suggests that about $1.4 billion went to the LDCs for energy access purpose, representing 35% of the total energy access finance by the Bank. 64% of the funding for energy access in LDCs went to Africa, and about 50% of this came between 2007 and 2008. This shows that only a small share of the energy access funding was directed to countries who need it the most and the attention to energy access in situation in Africa has received recent attention by the multilateral funding agencies. This imbalance in the funding is a major challenge for energy access funding.
In terms of investment by type of activity, household electrification received the highest amount—47% of the total investment (see Fig. 4). Within electrification investments, grid extension was the preferred mode, whereas off-grid electrification is gaining in importance. The lowest amount of investment went to cooking energy solutions, which clearly indicates the Bank's bias for prestigious large projects and inadequate support to the most pressing challenge of the poor.
(b) Another multilateral funding agency, the Asian Development Bank (ADB) has provided energy-related assistance of $13 billion between 1997 and 2008 but the highest level of support reached $2.7 billion in 2008 [10]. The energy sector investment has increased only recently but most of the investment went to large energy projects. India and Pakistan were two major

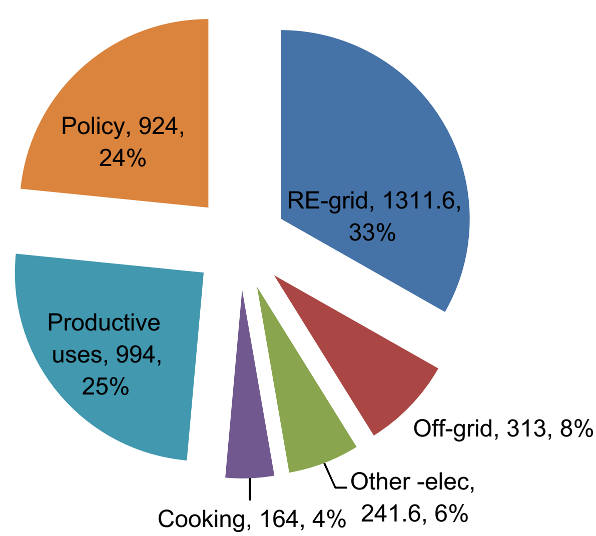


Fig. 4. World Bank's energy access portfolio. *Note*: the first figure is the investment amount in million dollars (current), and the second represents the percent share.
Data source: [25].

[4] [24] reported $490 billion for 1997–2005.

beneficiaries of ADB energy finances, while Sri Lanka and Afganistan are two other major beneficiaries. However, very little funding went to LDCs of the region and countries with poor energy access such as Nepal, Myanmar, Cambodia, Lao PDR, Bhutan, and Bangladesh. Similarly, conventional large power projects also received significant financing. It can be concluded from the above that energy access financing was not a major priority for ADB and the support did not reach the poor, less developed economies.

(c) The African Development Bank (AfDB) on the other hand reported that it has provided $3 billion to the energy sector between 1967 and 2007. 90% of the energy sector support went to power supply activities under two facilities: African Development Fund and African Development Bank window. The first facility supported rural electrification programmes while the second mainly supported large-scale power generation projects [17]. Like the World Bank, skewed preference for large projects and very limited attention to cooking energy supply can be observed.

Clearly, the multilateral funding agencies also ignored the energy access until recently and have focused on large projects, bigger markets instead of poorer economies and smaller countries.

Finally, one of the new financing mechanisms that have emerged over the past two decades relates to the carbon market instruments. Although the global carbon market has grown significantly and was worth $142 billion in 2010 [26], the market is dominated by the emissions trading of the European Union (accounting for 84% of the market value). The Clean Development Mechanism (CDM) of the Kyoto Protocol which was one of the main mechanisms of involving the developing countries in the climate mitigation process through financial flow from the developed world has seen a major fall in its market value: 7.4 billion in 2007 to 1.5 billion in 2010. The uncertainties about the future of CDM post-2012, the restrictions imposed by the European Union on the usage of Certified Emissions Reductions (CER) as a compliance instrument for the Emissions Trading System (ETS) and a reduction in demand due to economic recession have eroded its worth substantially. There is little incentive for any investor in the CDM now due to these developments. Moreover, only a few countries have benefited from the CDM so far: only 16,000 CER out of 605 million CER issued so far originated from the least developed countries [26]. Consequently, Africa as a continent has not gained much from the CDM despite a number of corrective measures taken by the CDM Executive Board. Energy access projects, being small-scale in nature, face prohibitive transaction costs to access CDM benefits and given the marginal nature of the CDM financial support, the barriers outweigh the benefits. However, the introduction of Program of Activities (PoA) and the decision to introduce standard baselines for such PoAs can help redress the problems [4]. As of January 2012, 58 PoAs for enhancing energy access of households have been designed—3 of which have already been registered [4].

The Global Environment Facility (GEF) has been another source of climate finance over the past 20 years. The facility has invested $10.5 billion in 2700 projects in 165 countries and arranged $51 billion in co-financing [27]. It has a dedicated fund for the least developed countries but most of the funding is directed towards climate change issues and not specifically for energy access.

The regional unevenness of flow of funds for clean energy investment is highlighted by [28]. Although the private sector has made about $150 billion new investment in clean energies in 2007, only 22% of the investment went to developing countries with two countries (China and Brazil) attracted most of this investment, leaving only $1.3 billion for Africa. Altough 85% of the funds went to wind, solar and biomass technologies, how much of this finance went for enhancing energy access is not clear. Given the regional distribution pattern, it can be inferred that energy access did not really benefit much. Therefore, despite a significant growth of the carbon finance market, it remains less accessible to small and poor developing countries and has not helped much in financing energy access.

Based on the above, the aggregate fund flow picture does not look very encouraging. The attention to energy access is a relatively new one and a selected set of large countries has often benefited. Funds for energy access have not flowed to countries who need them the most. New instruments have not been very helpful either.

2.3. Financing universal energy access

Based on the analysis of financial flows and investment needs for energy access, the magnitude of the challenge becomes quite clear. The present level of investment is much lower than what is needed to ensure universal energy access and the gap in funding will be significantly higher for low income countries.

For LDCs with high level of energy access problem, even investing the entire amount of capital now invested in the energy sector will not ensure universal energy access by 2030 [13]. It is estimated by [3] that LDCs will need an annual investment of $11.6 billion as against $2.5 billion invested in 2008 for the basic level of supply and the capital requirement will greatly increase if the medium and high scenarios are considered [13]. The challenge becomes even more daunting considering the limited multilateral funding agency support for the least developed countries. A 30:30:40 split of funds from the private sector, national governments and development assistance (including multilateral funding support) is considered by [1], which turns out to $15 billion per year each for the private sector and the governments, and $18 billion per year for the development assistance. The task becomes even more challenging due to economic recession in the developed world and donor apathy towards sustaining aid support over decades. The dim prospects of additional development assistance in the near futrue is highlighted by [4]. Thus a major change in the attitude of the funding agencies, development priorities of the states and the business strategies of the private sector will be required. It remains to be seen whether profound changes inherently assumed in the above suggestion are likely to happen or not.

Therefore, the challenge of financing universal energy access is a major global challenge. It will require an unprecedented level of investment in a large number of countries, most of which are in the low and middle income group, and who have limited experience of dealing with such high volume of investments. The past trend of fund flow is biased towards large countries but small, poorer countries will have to be the destination of funds in the future if energy access issue has to be addressed. The level of financial resources would have to grow a few folds compared to the present level and even the traditional sources may not be sufficient to bridge the funding gap.

3. Financing options and challenges

The financing challenge, particularly in the climate change context, has received international attention in recent times, since the Copenhagen Accord in 2009 (in relation to the Conference of Parties of the United Nations Framework Convention on Climate Change) where a promise was made for investing $100 billion per year in the developing countries by 2020 towards climate adaptation and mitigation. While the emphasis was on climate change, an extension of the focus to include energy access was also noticed subsequently with the UN decision to designate 2012 as the Year of Sustainable Energy for All. Thus the twin challenges of climate change mitigation and energy access provision have

Table 1
Summary of financing sources identified by [22].
Source: [22].

Source	Sub-category	Low carbon price case	Medium carbon price case	High carbon price case
Public finance	AAU/ETS auctions	US $2–8 billion	$8–38 billion	$14–70 billion
	Offset levies	$0–1 billion	$1–5 billion	$3–15 billion
	Martime transport emission levies	$ 2–6 billion	$4–9 billion	$8–19 billion
	Air transport emission levies	$1–2 billion	$2–3 billion	$3–6 billion
	Other carbon-related revenue		$25–33 billion	
	Financial transaction taxes		$2–27 billion	
Development Bank finance			$11 billion	
Carbon market finance		$8–12 billion	$38–50 gross; $8–14 billion net	$150 billion
Private finance			$20–24 billion	

shared concerns in this respect. This section reviews the literature on financing options and related challenges.

3.1. Review of financing options

The issue of mobilising $100 billion per year by 2020 was investigated by the UN Secretary General's High Level Advisroy Group on Climate Change Financing (AGF) [22]. Considering four sources of funds, namely public sources, development bank finance, carbon market finance and private finance, the Group found that in the likely scenario developed countries could mobilise $100 billion annually by 2020 for investing in the developing world. In the high scenario, significantly higher finance mobilisation is possible while the targets would not be reached in the low scenario (see Table 1 for a summary of the estimate). It is suggested that public finance from the developed economies can account for 40–45% of the total funding while carbon markets and development banks are identified as potential sources that can contribute another 20–25% while the rest will have to come from the private sector. However, a prolonged recession in the OECD economies and the potential for carbon leakage or relocation to developing countries can easily affect this outcome. Doubts have also been expressed in [4] that the development assistance is unlikely to meet the financing needs of energy access as there is the possibility of reduced flow of development assistance in the future due to economic downturn. The developing country governments will also be hardpressed for funds despite their commitments to energy access. Moreover, based on the present carbon market and FDI trends, it remains doubtful that the required volume of finance will flow to countries who need it most. This will by default imply a higher reliance on private capital to ensure energy access. However, a round table organised by Bloomberg New Energy Finance in association with UN Energy [29] indicated that if private capital has to flow to enhance energy access, the business climate has to change and countries would need to ensure the "core tenets of business ecology". Also the need for capacity building, identifying local champions and providing information was highlighted.

The enormous financing gap in Africa is recognised in [30]. It finds that against an annual investment need of $41 billion in the power sector, the continent is typically investing $11.6 billion. Closing the gap will be a challenge due to insufficient national public finances, limited benefits from the CDM, and poor private sector participation. New arrangements like Green Investment Fund, and the Energy+ initiative and the need for leveraging different funding mechanisms to achieve the energy access objectives are suggested in [4].

The direct access[5] to funding is emerging as a new concept in climate financing [33]. The Adaptation Fund under the Kyoto Protocol first used the concept and allowed the governments or the project implementing or executing agencies to approach the Fund directly. However, only one project using this mechanism is under implementation and therefore, its success cannot be easily assessed [33]. However, multilateral access is more widely used under GEF and CIF and even in the Adaptation Fund [31].

Thus, despite the recent commitments by various parties for supporting energy access initiatives, the issue of sustained financing of programmes remains. The role of local government financing becomes crucial in such a case. A review of the energy access programmes in the Asia and the Pacific [34] suggests that a firm commitment from the government for financial support through appropriate budgetary allocations was a key element in all successful cases. Embedding the projects in the overall rural development programme is also found to be another feature of successful programmes. [34] reports that two energy access projects in Nepal have successfully accessed CDM funding—one of them is based on biogas and the other is a micro-hydro project. At the end-user level, a combination of funding and financing mechanisms have been used, including capital subsidies, microfinance and donor assistance for market development. It suggests that a set of locally appropriate financing options, use of microcredit options to expand the market and reliance on productive use of energy as an alternative financing mechanism could be used to enhance energy access. A summary of specific country examples is presented in Box 1.

3.2. Financing barriers

Based on a survey of 38 financial institutions with experience of financing renewable energy projects in developing countries, a recent study [35] has identified a number of barriers to financing renewable energy projects by organising them under three main heads: level-playing field, easy market access, and political and regulatory investment risks. The undue competition from subsidised fossil fuels and transaction costs related to renewable energy project development are considered under the level playing field. The survey found that almost 80% of the respondents considered transaction costs[6] as an important barrier while more than 70% of them thought fossil fuel subsidies also affected the renewable energy promotion adversely (see Fig. 5). A corrolary from the above is that the CDM is just perceived as "icing on the cake" that is unlikely to play an important role in promoting renewable energies for electricity supply.

In terms of perception about easy entry, the survey reveals that unsustainably low energy prices and protective, non-competitive

[5] The term means accessing international finance by developing countries for climate mitigation and adaptation.

[6] Transaction costs act as a barrier to investment in renewable energies both in the developing and developed world but the problem can be more pronounced for small-scale projects used in energy access.

Box 1–State support for electrification programmes.
Source: [50]

China: Funds for rural electrification flowed from central and local governments and even local residents participated in providing funds. The decentralized electrification is either fully financed by the central government or through a cost-sharing scheme where the provincial government contributes a share. Strong state support and the ability to engage the local communities to the creation of local infrastructure have contributed to the success of China's near 100% electrification.

Brazil: The electrification programme PRODEEM was funded by donor agencies and the federal government. The rural power supply programme (LnC) and the Lights for All programme (LpT) programme were funded by the federal government although the states contribute about 10% of the cost. These programmes contributed to high rates of electrification of the country.

South Africa: The electrification under the Integrated National Electrification Programme was financed by the state budget and since 2003, has cost about $160 million per year. The financial support is expected to increase to $280 million by 2012. Although Escom initially thought the electrification programme could be self-financing but by late 1990s, it became apparent that this is unlikely and the state took the responsibility for funding the infrastructure development and subsidising supply. The improvement in electrification rate can be partially attributed to the state funding of the programme.

India: The new electrification programme in India (Rajiv Gandhi Rural Electrification Programme) that has increased the electrification rate substaintially is a central government sponsored programme. The central government provides 90% of the funds whereas the provicial government provides the rest for infrastructure development. Significant capital subsidy is provided for off-grid electrification projects as well.

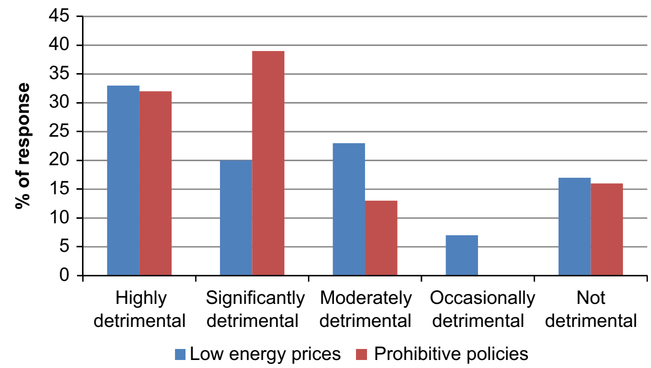


Fig. 6. Perception about easy market access.
Data source: [35].

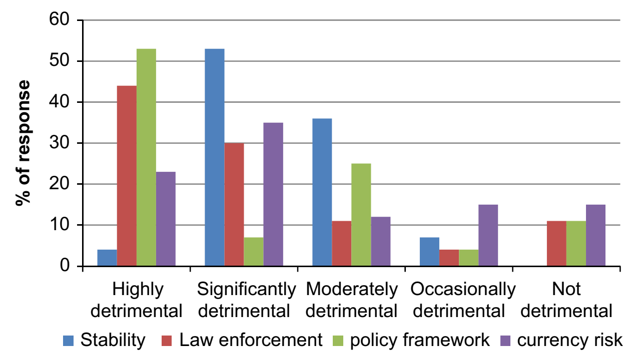


Fig. 7. Perception of political and regulatory risks.
Data source: [35].

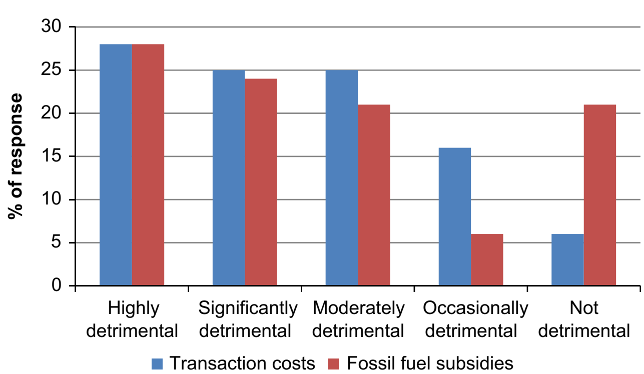


Fig. 5. Perception about level playing field.
Data source: [35].

and innovation-strifling electricity sector policies in developing countries have detrimental effects on private finacial capital flows to renewable energy development. Between 75 and 85% of the respondents consider that politically-motivated low prices and distortive sector policies are important barriers to investments (see Fig. 6).

Moreover, respondents perceive ineffective law enforcement, poor reliability of policies and support mechanisms, and political instability as major threats to viable investments (see Fig. 7). The respondents of the survey reported in [35] considered national renewable targets and feed-in tariffs as the most important incentives for renewable energy promotion but the CDM did not figure as a favourite incentive. The studyrecommends that countries should ensure a level-playing field, provide easy access to their electricity market and mitigate risks by setting national renewable energy targets, removing fossil-fuel subsidies, providing incentives for investors, reforming political, economic and societal structures, and by adopting international risk-mitigation instruments [35]. However, this is easier said than done but can energy access wait for satisfaction of such pre-conditions?

Using a meta study of evaluation of 17 GEF projects, [36] presents another interesting study of identifying barriers for energy efficiency projects. It identified 20 barriers and grouped them into four severity categories (namely show-stopping barrier, significant barrier, not so important barrier and no barrier) for four sets of stakeholders (namely consumers, suppliers, financiers and policy makers). It thus maps the relevance and importance of seven generic barriers (namely igonorance, lack of motivation, lack of expertise, lack of access to technology, lack of cost effectiveness, lack of business model or demand and lack of affordability) for different stakeholders (see Table 2). Although the study was done for energy efficiency, it can be relevant for the energy access challenge, with some adjustment. It is worth noting that lack of cost effective solutions can be a show stopper and can hinder energy access investments in many countries.

A distinction between the project-based barriers and programme- based barriers is made in [38]. The initial barriers faced by an investor are classified as the "first generation barriers" and include, among other, low returns on investment, high transaction costs, lack of experience with energy access financing, and unsuitability of existing credit facilities for financing these projects. Based on the experience of Asia and the Pacific in promoting renewable energies for energy access, [38] reported that through a process of trial and error, most countries of the region have an understanding of the first generation barriers and can resolve them as well. However, the scaling-up experience is quite limited

Table 2
Key barriers to market development.
Source: [36].

Barriers	Consumer	Suppliers	Financiers	Policy
Show-stopping barrier	Ignorance Lack of access	Lack of cost effectiveness	Lack of cost effectiveness	
Significant barrier	Lack of affordability	Lack of expertise Lack of affordability Lack of business model	Lack of expertise	Lack of expertise
No important barrier		Lack of access		
No barrier	Lack of interest Lack of expertise Lack of cost effectiveness	Ignorance	Ignorance Lack of business model	Lack of interest Ignorance Lack of affordability

and there is poor knowledge about successful scale-up models. This leads to the second generation barriers to ensure an effective transition from projects to programmes.

Based on an email-based survey of financial experts, [4,5] found that 85% of the respondents considered financial sustainability of projects is the essential factor ensuring long-term viability of rural electrification projects. 67% of the respondents considered that a public–private partnership would strengthen the financial sustainability of such projects. In respect of financing, micro-finance and linking electrification with productive activities was highlighted as a very important factor. 72% respondents considered renewable energy funds "the most suitable financial instrument to deal with renewable electrification projects". Revolving funds were identified as the best option for end-user financing, followed by productive uses and micro-finance. Lease instruments were considered least suitable for these markets.

The barriers to accessing climate finance by small projects were highlighted in some studies. For example, [37] highlights the barriers faced by cook-stove promotion programmes in accessing climate finance such as the the CDM which has recently approved a methodology for emission reduction from small-scale cookstove projects. Beyond the normal CDM registration, verification and validation processes, improved cookstove programmes face further barriers as follows: there is no ready additional finance available for the implementation of such projects; the rigid requirements of the CDM in terms of verification and performance requirements can hinder such programmes; in addition, measurement and verification of emissions, possibility of leakage, and changes in the climate policy or carbon finance policy can also affect the programmes. Similarly, [34] also underlines the difficulties in accessing carbon finance for energy access projects. Lengthy processes and high transaction costs act as disincentives but the greatest barrier is the uncertaintly prevailing in respect of post-2012 situation.

An analysis of market barriers in using solar PV for productive uses is found in [39] along with an example from the Indian agricultural sector. Using a case study of Punjab (India) where a programme of PV in the agricultural sector has succeeded with government providing subsidies to agricultural users, the author suggests that the call by neo-institutional economists (NIE) for getting institutions right is not sufficient to address the problem because it does not offer viable solutions for political interference in the barrier removal process. The author suggests that state policymakers should look beyond NIE and try to improve and expand PV markets by considering the market barriers, political constraints, and cultivating locally appropriate service models.

To conclude, mobilising financial resources to ensure universal energy access remains a major challenge. The financial needs of poorer countries are likely to be beyond their own financial means and the governments of budget-constrained developing countries may not be able to contribute much to finance such demands. International support will be required but the public finance may not be easily forthcoming and may not reach the countries that need it the most. The present support of the multilateral finance organisations is biased towards large-scale energy projects and often disproportionately benefits large developing countries. Thus if universal energy access has to be achieved, these trends need to change so that funds can flow to poorer countries at the right time, in right volume. These investments have to be considered from the societal perspective of creating socially beneficial infrastructure that go beyond the business case of profit-oriented private investments. While the developing countries need to remove major barriers that hinder large-scale mobilisation and use of funds, it remains doubtful that such corrective actions will yield results in the short-term but the universal energy access provision cannot wait for such changes to take place. There lies the dilemma and challenge.

4. Specific financing approaches for off-grid electrification

According to [40], capital is required at various stages of an off-grid electrification business—upstream of the project, for running the project and even downstream to support the customer or the business transaction. Different financial instruments are available to cater to the needs [41]: assistance, funds, micro-finance, fiscal instruments and others (see Fig. 8). This section tries to capture this distinction by considering project-level financing and end-use level financing.

4.1. Project-level financing

Off-grid projects have often relied on finance from donor agencies and budgetary support from the state. Any investor intending to enter the off-grid business would need the start-up capital and the ability to take risks in the new business. The seed capital is an early stage finance mechanism for this purpose that is used to convert an idea to a new business, particularly in the case of small and medium sized businesses. E+Co is a specialized entity in respect of renewable energy business [40]. Although venture capitalists play an important role in industrialized countries in taking risks of innovative businesses, the prospect of persistently low returns in the off-grid businesses restricts the potential of venture capital. [40] suggests that the donor agencies could fill this gap instead.

Private investors or agencies involved in the service also used the following sources [42]:

- Equity or debt financing by the government—In Mexico, the government provided for the initial capital required for the equipment either through an equity contribution or through a loan.
- Asset-based lending—Investor borrowed funds from banks or financial institutions by mortgaging its PV assets or other

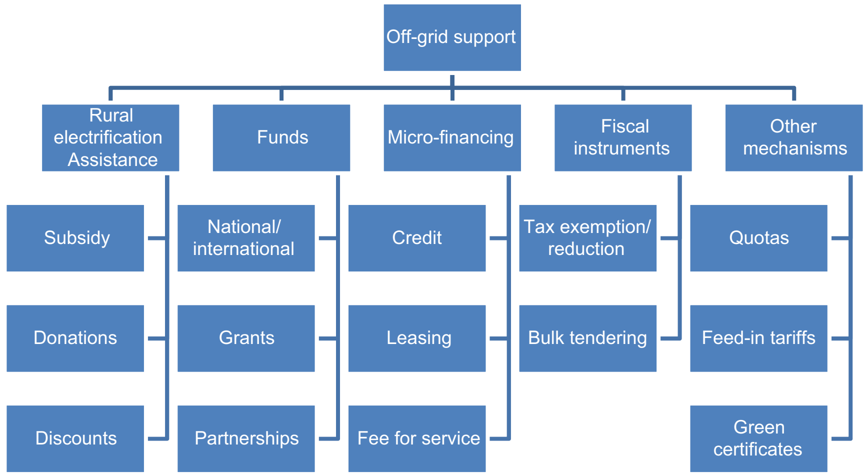


Fig. 8. Financial instruments for off-grid electrification.
Source: Adapted from Ortiz et al. [41].

assets. The limited size of these assets however restricts the loan amount. Banks often require other security to reduce its risk exposure, thereby making the borrowing unattractive for the investor.

– Non-recourse financing—This follows from the project finance literature where the company borrows money based on its project cash flows instead of relying on the parent company's balance sheet. However, it is noted that this option has been rarely used but the Rural Electrification Co-operatives in the Philippines raised funds through this mechanism from the National Electrification Administration.
– Supplier credits—PV suppliers offer credits to dealers or aggregators to improve the cash flow for a short period. Generally, these credits tend to be short (six months or so). Indonesian PV companies received such supplier credits.

Once a business starts operating, its operating capital needs increase to meet the short-term and long-term capital needs. Very few commercial lenders provide funds to off-grid electricity businesses and consequently, support mechanisms are required in the form of "lines of credit, credit enhancements for loan provision and SME growth capital funds" [40]. Based on a review of off-grid rural electrification experience in developing countries especially through the World Bank initiatives [43] suggests that if governments want to reach the poorest section of the population, subsidies perhaps cannot be avoided but these have to be well targeted and appropriately designed to avoid market distortions. [6] argues that there is still a huge affordability gap amongst rural poor and therefore subsidy plays an important role. But the subsidies may be attracting new suppliers in the market and may not be creating a sustainable business model.

[44] asserts that to become sustainable an off-grid project has to be beneficial to all main stakeholders—consumers, service providers, financiers and government. This needs to consider the government's intentions, subsidy commitment, and regulatory rules; promote productive and institutional energy use that generates income opportunities; and take the possibility of international co-financing into account. [44] acknowledges that designing an off-grid system is not an exact science—it is made more complex by a combination of factors including among others high cost, poorer consumers and new technologies. It also suggests that the question that requires investigation is how and when an off-grid investment complements grid expansion. It recognizes that although a few off-grid operations are commercially viable (example include PV in China and Kenya, some PV operations in India, pico-hydro in Laos and Vietnam and micro-wind in China and Mongolia), most off-grid electrification may require subsidies. Therefore, enhancing affordability through subsidies, consumer financing, low-cost technology options and policies and business practices is important. Further, financing arrangements can complement subsidies. International co-financing such as through GEF, CIF, and CDM can help. By increasing the size of the consumer base through micro-finance, the affordability and viability of projects can be enhanced. Duty or import tax waiver or reduction and avoidance of multiple taxes are commonly used in this respect.

4.2. *End-use level financing*

The issue of end-use financing is not a new one. A review of practices in the 1990s along with a discussion on alternative types of financing arrangements can be found in [42,43,45]. A review of alternative end-users financing options can be found in [40]. These include:

(a) Small-scale lending: where multilateral lenders provide funding to organizations/agencies with adequate institutional arrangements for administering the financing programme. UNDP/World Bank, GEF and other government funds (e.g., Netherland's project Finesse) come under this category. Under Finesse, multilateral lenders provide loan to a local agency that retails the loan to end-users.
(b) Micro credit—Because the cost of an energy appliance (e.g., SHS) is generally high compared to a rural household income, availability of consumer credit facilities is an important aspect. [45] reported that an Indonesian company, Sudimara Solar operated customer financing scheme and achieved a 100% pay-back record. Box 2 provides further details on micro-financing.[7]
(c) Leasing arrangements—Here the company supplies the appliance with upfront investment and receives a monthly charge from the consumers towards recovery of the cost. The system remains the property of the company. [45] reported that such a system was operated by a company called Soluz in Dominican Republic. Often Energy Service Companies (ESCO) follow this approach as through aggregation of demand the company obtains a better deal from the lenders and appliance suppliers while the consumers benefit low rental charge.

[7] See [46–48] for other country cases and examples.

Box 2–Micro-finance schemes.

Commercial banks and formal financial institutions often do not reach rural and remote areas. An alternative has arisen in the form of micro-finance to fill the gap. There is now considerable experience in using micro-finance for development purposes and in enhancing energy access in developing countries. More than 500 million people in the world now have access to micro-finance [46]. Microfinance organisations have developed a number of arrangements [46]:

(a) Financing provided hand-in-hand with technical support: In this arrangement, the micro-finance organization enters in an association with the service provider and work towards a common goal of providing a complete package of product sale backed by a tailored financial service. This arrangement has been used in SELCO (an India solar energy provider) and SEWA (a micro-finance organization).
(b) Energy companies lending directly—Some energy service companies provide micro-finance directly to consumers by availing financial support/resources from third-parties. This has been used in some Latin American countries and in the Caribbean. The Soluz enterprises used this model.
(c) Subsidies linked with microfinance—Micro-finance organizations often receive subsidies or grants for onward lending to final users. Micro-finance is also used to bridge the project cost and subsidies. SEEDS uses this model and is participating in a World Bank supported project where it provides 25–30% of the energy access project costs.
(d) Conventional loans—In this case, the micro-finance organization plays the role of a conventional bank and provides small credits to consumers. Amret in Cambodia relies on this form.
(e) Bulk purchase of equipments for onward lending—Here an umbrella organization procures the equipment in bulk and lends them to local micro-finance organizations.

However, microfinance organizations also face a number of risks: finding a suitable partner is not easy; as consumption-oriented loans are normally based on credit-worthiness of recipients, mass-scale penetration of energy consumption loans may be difficult; and the risk of non-recovery of energy equipment cost is high.

Moreover, many countries do not have proper regulatory arrangements for the microfinance sector. While such organizations emerge as informal activities, there is also the risk of misappropriation of consumer money and poor quality of services. Accordingly, [47] recommend that governments should create enabling environment for microfinance sector and strengthen monitoring, evaluation and disclosure of microfinance activities for energy.

(d) Revolving funds: These funds are generally provided by philanthropic organizations or donors and are operated by community-based organizations that lend funds to individuals often at a favourable rate than the banks do. Initial seed funds are provided to install systems and repayments are then used to finance more systems. This has been generally used in the initial stages of projects such as Enersol NGO in the Dominican Republic; Solanka NGO in Sri Lanka; and the BANPRES project in Indonesia.

Generally projects tend to use a combination of end-user financing mechanisms [34]. From Table 3 it can be seen that projects tend to rely on a combination of instruments that are appropriate locally. In most cases direct subsidy (capital and in some cases energy-related) forms an integral part of the end-user financing mechanism for enhancing energy access. However, the issue of ensuring financial sustainability of the business enterprises and the burden on government budget cannot be overlooked.

Table 3
End-user financing mechanisms used in energy access projects.
Source: [34].

Project name	Financing mechanism					
	User contribution	Direct subsidy	Micro-financing	Loan	Retailer finance	Fee for service
DPBURC China project	X	X		X		
StoveTec	X		X		X	
Tide India	X			X	X	
RGGVY	X	X				X
IWM Nepal	X	X	X	X		X
BSP Nepal	X	X	X	X		
REDP Nepal	X	X	X	X		
RERED Sri Lanka	X	X	X	X		
Sunlabob Lao PDR	X					X

There is also some suggestion that a premium renewable energy tariff scheme along the lines of feed-in tariff can be used in rural mini-grid systems. [49] provides such an argument and shows that it can be a viable alternative. However, it is not known whether such a system has been applied in reality yet.

To conclude, both upstream and downstream financing options play an important role for off-grid electricity supply. Rapid expansion of off-grid electricity supply in remote rural areas would require expansion of financial services and financing options. While upstream finance receives greater attention, sustainability of the electrification efforts would also require a greater attention to downstream activities. Balancing these challenges would require involvement of multiple stakeholders—government, financial organizations, microfinance organizations and energy suppliers.

5. Conclusion

Renewed focus on universal energy access in recent times has necessarily brought the underlying financial challenge to limelight. Although the estimates vary from a low of $11 billion per year to $ 120 billion per year with a mid-range value of $50—60 billion for the next two decades, the size of investment required is significantly higher than traditional levels for energy access provisions. The funding gap will be more acute in least developed countries where the energy access level is very low and where the traditional barriers to investment are more profound. This review highlighted that even the multilateral funding agencies actively involved in development of poorer countries have not paid adequate attention to energy access funding and have focused on large projects and large countries. There is an urgent need to redress this bias.

Our review also highlights that the development assistance will not be sufficient for promoting energy access. Despite pledges for support to noble causes, the developed country funding constitutes only a small fraction of the overall financial resources. Given the unfavourable economic condition in many developed countries at the moment and aid fatigue, one cannot solely depend on such sources. Developing country governments and the private sector will have to play an important role. Governments would have to commit not only funds but also create an

enabling environment for private businesses, micro-finance organizations, and management and implementation of energy access activities in a timely and orderly manner. Removing barriers to investment and business promotion, and supporting innovative approaches through collaboration, learning from others and experience sharing will be very essential.

In this respect, the issue of south–south co-operation cannot be overlooked. A lot of experience and innovative approaches are being used in the developing world that can be easily tried and replicated in other contexts. Similarly, the financial support from developing countries itself can be an additional source of finance. Already, China has been actively involved in many infrastructure development projects in Africa. Although China's investment is flowing to resource-rich countries (often rich in petroleum resources), some future support to energy access from China and other developing countries may be possible.

Although carbon finance and such innovative mechanisms have not played a major role in energy access so far, the carbon market is likely to grow in the future. Creation of new climate funds (such as Green Investment Fund or Climate Investment Fund) and inclusion of energy access of least-developed countries in some of their remit can help but the barriers related to transaction costs and complex processes cannot be overlooked either.

Overall, the challenge to financing energy access remains a major global issue and requires a concerted effort of all stakeholders to find tangible solutions to the problem.

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